The New Technology

It was becoming clear by the mid-sixties that there was no alternative to technological change in agriculture for achieving self-sufficiency in food grains. Even those countries in Asia which could carry out radical land reforms and build up an adequate infrastructure for agriculture had taken to the path of modernising agriculture. Japan took the lead in this direction and China followed suit even after successfully experimenting with structural changes and mobilisation of a growing labour force for capital construction in agriculture.

Characteristics of New Technology

The distinguishing characteristic of the new technology lies in the substitution of traditional robust but low-yielding varieties of seed by the so-called high-yielding variety. These seeds have the physiological attribute of being able to turn large amounts of soil nutrients into grain rather than leaf growth. This enables the plant to produce higher yields, especially so if the supply of nutrients in the soil can be increased. This in turn creates the demand for chemical fertilisers to supplement the natural fertility of the soil. Because these contain nutrients in concentrated form, they have to be applied with adequate supplies of water to enable the plant to absorb them without damaging itself. A lack of adequate water supply not only reduces the yield but may do so substantially.

Better Agricultural Practices

This seed-fertiliser-water package in turn calls for better agricultural practices for the effective utilisation of the technology.

First, the plant requires the fertiliser-water input at particular stages of growth to give the best yields.

Secondly, as fertilisers can be absorbed by weeds as well as by the plant, effective weeding is required to prevent waste of expensive fertiliser.

Thirdly, while the HYV seeds give higher yields, they are more prone to damage from excessive watering. For example, shorter-stemmed dwarf varieties are more liable to be flooded. They, thus, require more effective water control and better drainage. The need is for controlled and adequate water supplies.

Fourthly, being relatively new and non-acclimatised strains, they are more prone to local pests and diseases than established indigenous varieties and therefore, require a supply of germicides and pesticides.

Two further physiological characteristics of the new seeds are that they are quicker maturing than the traditional varieties and they are non-photosensitive. On the one hand, these two characteristics give rise to a shorter harvesting period, thus making it possible for farmers to practise multiple cropping, enabling them to use more intensively a given amount of land. Fertilisers, by enabling more production per acre to be achieved, and the quicker maturing HYV seeds, by making it possible to practice double cropping during the year, both act as land-saving innovations. Hence, their attraction to a land-hungry south Asia. On the other hand, as the crop may be ready for harvesting during the monsoon season at a time when the cloud-cover has not yet dispersed, a possibility of loss of output due to a lack of drying and storage facilities is also opened up.[1]

Thus, the basic technological characteristic of the new technology is the application of a number of inputs which are complementary to each other. The application of these joint inputs yields much larger volumes of output of food grains as a result, largely by increasing yield per acre. However, in order to assess the impact of the technology on Indian agriculture, we have to also take into account some of the economic characteristics of that technology. In an economy where labour is relatively plentiful, it has low opportunity cost. Most agricultural holdings in India use either family labour or fairly low-paid agricultural labour, neither of which, generally speaking, can command high levels of alternative earnings. For traditional agriculture, the most expensive input, other than land, is bullock-power. The new inputs are mostly of manufactured origin, such as fertilisers, pesticides or pumps, and are more expensive. In non-rainfed agriculture, there are also costs attached to irrigation, in the form either of the capital costs of sinking a well or installing a pump or running costs in the form of purchase of diesel fuel or payment of water rates.

Economic Aspects of New Technology

The new practices, therefore, are much more expensive to the farmer. This has three implications. First, the extent to which the various inputs are applied in practice depends not on some technologically efficient dosage but on an economically optimum one. This depends in turn on the relative prices of inputs and outputs facing the producer. Minhas and Srinivasan have shown that fertiliser application is subject to diminishing returns, the economically optimum dose being smaller than the technical optimum. As technologically some of the inputs are complementary, the extent to which the application of a particular input can be profitably pushed depends also on the availability of, and the ability to purchase, other inputs. For example, the degree of fertiliser application that is profitable will depend on the availability of water and on the ability of a farmer to purchase the use of both inputs.

Secondly, the new technology is only worthwhile in terms of private benefits, e.g., if the farmer receives yields which are not only larger than traditional varieties but are substantially so, to make up for the additional variable costs of cultivation. This in turn requires, thirdly, a more intensive use of the fixed factor, e.g., land. The new technology opens up the possibility of multiple cropping; the economic imperative drives the farmer to it. This is compounded by the fact that while the new technology yields larger outputs, it is also more subject to risks. We have noted that the HYV seeds are prone to damage from flooding, water scarcity and pests. Moreover, because the farmer is a newcomer to these practices, he is also ignorant of how to respond if something goes wrong. Additionally, where he is involved in substantial cash outlays in order to utilise the new technology, he bears a liquidity risk. This is reinforced by the fact that very often, the farmer may have to resort to borrowing in order to meet the additional costs of cultivation. A crop failure saddles him with the burden of debt.

These economic aspects of the new technology are as important as its technological characteristics to our understanding of the impact of the 'green revolution' upon the agrarian economy, especially in relation to the problems of mechanisation and of unequal incidence of acceptance and use between large and small farmers. That impact can best be studied in terms of the effects of the new technology on output, employment and the regional and interpersonal distribution of gain arising from the adoption of that technology.

Three Phases of Green Revolution

Gulati and Fan (2008)[2] identify three phases of the green revolution.

The First Phase, 1966-1972

To end its dependence on P.L. 480, India, prompted by the minister of agriculture at that time, C. Subramaniam adopted a new agricultural strategy to boost grain production accompanied by remunerative support price for farmers. In January 1965, the Agricultural Prices Commission was set up to recommend a MSP, followed by the Food Corporation of India (FCI) to take charge of the logistics of procuring major agricultural commodities (Gulati, 2003). In the same year, India took a bold step by allowing the introduction of new high-yielding seed varieties (HYV) of wheat from Mexico. In 1966, India ordered the import of 18,000 tonnes of HYV wheat seeds that were distributed in the highly irrigated areas of Punjab, Haryana and western Uttar Pradesh where the past investments in irrigation had paid rich dividends.

The new seeds could yield more than double the existing levels and thus had the potential to dramatically increase wheat production and food grain supply. Under the new agricultural policy, the spread of HYVs was supported by public investments in fertilisers, power, irrigation and credit.

The total amount of food grains harvested increased from 74 mt in 1966-67 to 105 mt in 1971-72, and that year India became self sufficient, with grain imports declining to nearly zero.

These outcomes would not have been possible without the favourable pricing policy that provided farmers with adequate incentives, the dynamism of the national research system that proceeded to indigenise the new seeds to tackle their shortcomings (Gulati, 2003), and the availability of inputs including canal water, fertilisers, power and credit. In view of the strategic importance of these critical inputs, it was the responsibility of the government to ensure that farmers had affordable access to them. Subsidies thus, became an instrument of agricultural policy in the late 1960s and acquired greater importance in the 1970s (Gulati and Narayanan, 2002a). The role of credit began to be important after 1969 following the nationalisation of banks.

Improved agricultural production resulting from modern input and technologies "trickled down" to the poor and led to a rise in farmer income, while output growth and increased grain supplies caused a decline in real food grain prices, benefiting the poor. Thus, rural poverty declined significantly in this phase, from 64 per cent in 1967 to 56 per cent in 1973 (Datanet India Pvt. Ltd., 2006). Several government anti-poverty programmes were also introduced during the Fourth Five-Year Plan in the early 1970s. (Gulati and Fan, 2008)

Debacle and the Second Phase, 1973-1980

After the nationalisation of the banks, Prime Minister Indira Gandhi took other steps to extend the role of the state in key areas of economic management. In agriculture, private wholesale traders came under attack because, due to their speculative motives, they were regarded as responsible for fluctuations in food grain prices and supplies. Thus, in 1973-74 the government took over the wholesale trade in wheat, which proved a disaster (Chopra, 1981) and therefore, it was soon abandened. Wheat procurement was hindered by limited supply resulting from droughts in several states in 1972-73.

Following two consecutive droughts in 1972-73, food grain production decreased by 7.7 per cent (India, Ministry of Agriculture, 2003), and India slid back into the trap of food grain imports of an average of about 4 mt a year from the United States between 1973 and 1976.

After the oil shock, the government increased fertiliser subsidies to prevent a drop in consumption following the rise in fertiliser prices. In 1977, the retention price scheme was introduced for urea, the predominant fertiliser in Indian agriculture. During the 1970s, other input subsidies grew in importance within the state budget (Fan, Thorat and Rao, 2004), and the subsidy bill excluding fertilisers grew from Rs. 10 billion at constant prices to Rs. 33.2 billion, or from 0.5 per cent to 4.0 per cent of agricultural GDP between 1973 and 1980 (Gulati and Narayanan, 2002a).

Also during this period, groundwater irrigation increased in importance, with its share rising from 0.55 per cent to 19.5 per cent between 1960 and 1975 (Datanet India Pvt. Ltd., 2006) on account of private investment in tubewells by farmers who reinvested the income from the earlier burst in foodgrain production. As a result, power subsidies for water pumping grew dramatically, reaching 44 per cent of the total input subsidy at the start of the 1980s (Gulati and Narayanan, 2002a).

The extension of HYV technology from wheat to rice, favoured by the growth of tubewells, spread the green revolution to new areas, marking a new phase in the expansion of domestic production. From 1972-73 to 1979-80, production as well as yields of food grains showed remarkable growth, at 3.1 per cent and 2.5 per cent, respectively, and rural poverty declined from roughly 56 per cent to 50 per cent (India, Ministry of Agriculture, 2004).

The Third Phase, 1981-1990

In the 1980s, India consolidated its status as a food self-sufficient country. Rice production soared to 63.8 mt in 1986, up from 37.0 mt in 1964. Wheat output grew, too, from 12 to 47 mt in 1986, a year in which India had her first 25.4 mt of grain buffer stocks (India, Ministry of Agriculture, 2004). When in 1987 the "worst drought of the century" struck the country, food needs could be easily met without any loss of lives (Gulati, 2003).

During this phase, the HYV technology spread eastward to states like West Bengal and Bihar, which experienced surpluses in rice, with output over the 1980s growing at 5.0 and 3.7 per cent, respectively (Datanet India Pvt. Ltd., 2006). However, in the rest of the country the green revolution ran out of steam by 1985 once the new seed varieties had been widely adopted in the main producing regions. Yields for rice and wheat that had grown, respectively, by 3.5 per cent and 4.5 per cent per annum between 1967-68 and 1984-85 slowed down to 2.3 and 2.4 per cent per year between 1985-86 and 1999-2000 (IFPRI, 2004). With the HYV technology exhausting its impact in the mid-1980s, input subsidies were steadily increased to continue sustaining food grain production growth. By 1991, input subsidies had grown to 7.2 per cent of agricultural GDP as compared to 4.4 per cent in 1980 and 2.0 per cent of total GDP from 1.5 per cent in 1980 (Gulati and Narayanan, 2002a).

Throughout the green revolution, Indian agriculture laboured under a strictly regulated policy regime characterised by wide restrictions on production through licencing requirements and barriers to entry, as well as controls on pricing, movement and private trading of agricultural produce. On the external front, too, the sector was burdened with various tariff and non-tariff barriers to agricultural trade flows. (Gulati and Fan, 2008)

The high level of protection accorded to industry produced high industrial prices and adverse terms of trade (ToT) for agriculture, reducing the relative profitability of the primary sector. Agriculture was overall net taxed (disproteced) on account of the overvalued rupee, which produced an anti-export environment for agriculture. The objectives of this framework were broadly dictated by the dominant strategy of the pre-reform era, that is, food self-sufficiency resulting from domestic supplies, aiming to: (1) ensure inexpensive food for consumers, (2) protect farmers' incomes from price fluctuations, and (3) keep the balance of payments in check. (Gulati and Fan, 2008)

Reform Period, 1991 to the Present

Although the reforms were implemented in off-farm activities, they affected agriculture in at least two important ways (Landes and Gulati, 2003). First, the higher rate of economic growth and the consequent rise in per capita incomes resulting from the 1991-1993 reforms had a significant impact on food demand. Higher per capita incomes, growing at 4.5 per cent per annum in this phase as opposed to 3.6 per cent in the 1980s (WDI, 2004), led to the diversification of food demand into non-food grain crops such as fruits and vegetables, as well as meat—mainly poultry—and dairy products. Second, the lowering of industrial protection significantly improved the incentive framework for the sector through improvement in the domestic ToT between agricultural and industrial prices, which rose from 0.9 to 1.2 between 1991 and 2000. (Gulati and Fan, 2008)

Improved ToT for agriculture in turn resulted in an increase in the profitability of the primary sector relative to industry and led to an increase in private investments, which are now double the public investment in agriculture. These were increasingly directed to the production of horticultural produce, poultry, fish, milk and eggs in response to booming consumer demand for these high-value agricultural products, leading to a remarkable growth in output of these commodities during the 1990s relative to the previous decade.

As a result of these developments, agricultural GDP went up from 3 per cent in the 1980s to 4.1 per cent in the aftermath of reforms between 1991 and 1996.